EXAMPLE OF A HIGH-SPEED, SIDE-IMPACT, CAR CRASH RECONSTRUCTION USING A PLANAR MULTIBODY SOFTWARE

P. A. Simionescu[1], and Ion Preda[2,*]

[1]Texas A&M University Corpus Christi, USA
[2]Transilvania University of Brasov, Romania

Abstract. The paper presents an example of Working Model 2D multibody software use in the reconstruction of a high-speed side-impact accident of two automobiles. The simulation (part of a contested judicial litigation) allowed to clarify whether at the time of the accident, the impacting vehicle was impermissibly passing to the left of the continuous center line.

Keywords: accident reconstruction; side impact; multibody simulation

1 INTRODUCTION

The purpose of traffic accident reconstruction is to estimate the velocity of the vehicle(s) at the moment of collision. Other objective of the reconstruction is the determination of the location of the vehicle(s) in the cases when evidence is insufficient to estimate their positions and orientation at the moment of impact.

The velocity of a vehicle in an accident can be determined using possible tire marks left on the road surface, or by measuring the amount of deformation caused during impact [1-2]. In mapping the accident site, debris scatter analysis and driver and eye-witness statements are also utilized. Nowadays, substantial use is made of computers in traffic accident analysis. Crash analysis computer programs serve investigators in determining the relative velocity between the two vehicles (Δv) prior to impact - an essential piece of information in most accidents. There are instances however when a post-impact analysis is also necessary to clarify the circumstances of the accident.

The present paper considers such a scenario, i.e. of a court-contested case where the impacting vehicle was allegedly passing to the right of the continuous center line. The reconstruction is further complicated because part of the information about the accident has been lost, in particular the measurements of the deformation of the two vehicles. A two-car side-impact accident will be analyzed using Working Model 2D multibody simulation software [3], for the purpose of establishing the location of the two vehicles prior to impact. Additionally, internet-based digital maps have been utilized to accurately reconstruct the accident scene based on the police-report measurements.

2 ACCIDENT DESCRIPTION

The vehicles involved in the accident were a SKODA Octavia (the impacting vehicle or bullet vehicle), and a BMW Touring (the impacted vehicle or target vehicle) – Figure 1. The accident occurred at the intersection of a four-lane road with a secondary road (see Figure 2). The BMW was entering the main road from South-East and was struck in the middle of its left side, severely injuring the driver. The accident happened during daylight, in heavy traffic. The road surface was in favorable conditions with no precipitation. There was only one short, inconclusive tire mark left on the road (Figure 2). The debris produced during impact yielded little information to the police crew that mapped the accident scene.

Fig. 1. Post-accident photograph showing the two vehicles involved i.e. a SKODA Octavia (the bullet vehicle), and a BMW Touring (the target vehicle)

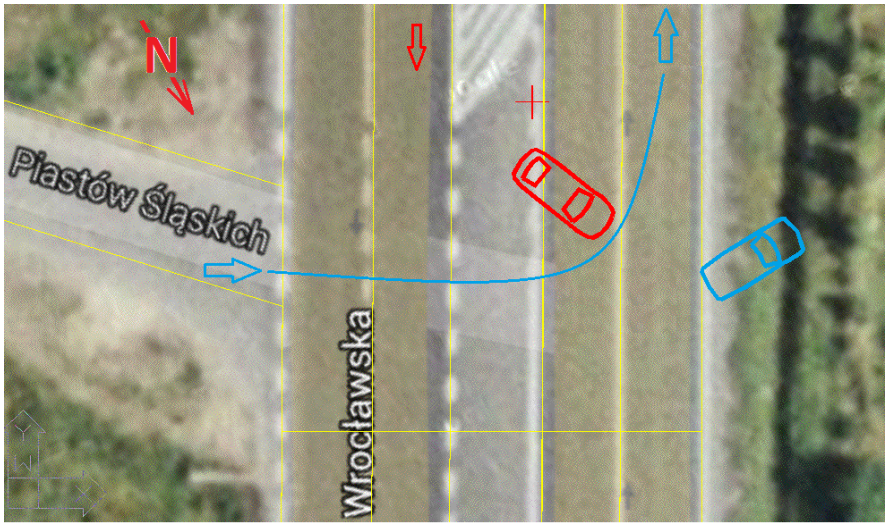


Fig. 2. Accident scene showing in blue the intended direction of travel of the BMW, and in red (the arrow) the alleged travel direction of the Skoda. The only tire mark identified at the scene has been marked on the figure with a red plus sign

Fig. 3. Intersection where the accident occurred, viewed in the intended direction of travel of the BMW

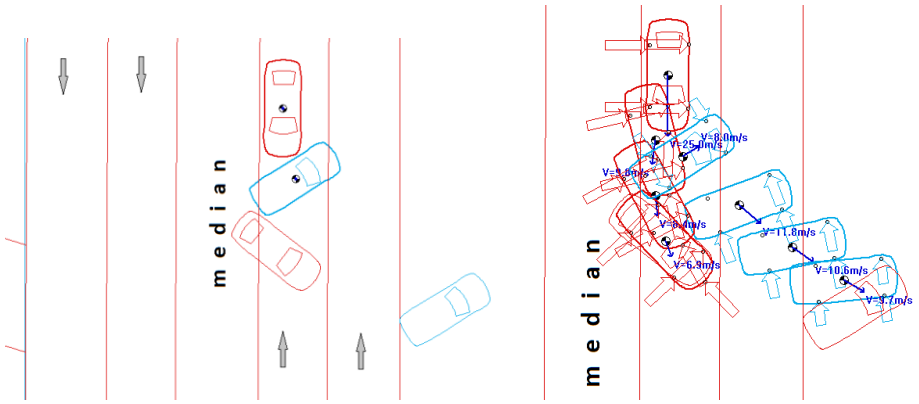
What is contested about this accident were the pre-impact speed of the SKODA, and whether it was passing to the left of the median at the moment of collision. According to the statements of its driver, the SKODA was traveling on the second lane at about 90 km/h, he was caught by surprise by the appearance of the BMW, and had no time to apply the brakes to avoid a full impact. By contrast, the driver of the BMW claims that at the moment of the collision the SKODA was passing left of the median visible in Figures 2 and 3.

3 COMPUTER SIMULATION

There is a number of computer programs available for car-crash reconstruction that can simulate either 2D or 3D road accident events. Examples are CRASH/EDCRASH, SMAC/EDSMAC, WinSMASH, PAM-CRASH, PC-CRASH, LSDYNA etc. [4-11], or in-house software as described in [12-15]. Working Model 2D (WM 2D) considered here is a general purpose planar multibody simulation software, able to perform dynamic analysis of constrained bodies with contact and friction. Its capabilities can be enhanced by the use of a native formula language, and by interfacing it with Microsoft Office Excel and MATLAB.

Part of reconstructing the accident under consideration, a scale drawing of the scene has been generated within AutoCAD, based on the police report data, and using an aerial view of the intersection as background image [16]. A layout of the scene has then been exported to WM 2D via the DXF format. Secondly, top views of two vehicles (see Appendices 1 and 2) were drawn at scale in AutoCAD, and were then exported to WM 2D as polygonal bodies. The mass of the SKODA was assumed to be 1495 kg, and the mass of the BMW was assumed to be 1615 kg. Lacking precise data, the centroidal moment of inertia of the two vehicles was considered to be the same and equal to 2750 $kg \cdot m^2$. No adjustment of the centers of mass of the two vehicles has been performed beyond the default locations assigned by the software to the bodies representing the two vehicles. The common restitution coefficient was set equal to 0.22, which according to references [17], [18] and [19] is a probable number in case

of high-speed collisions of automobiles. Also, as defined in WM 2D, it was adopted a friction coefficient between the two vehicles equal to 0.28, which is the ratio between the tangential and normal impact forces assigned by the software [20].



(a) (b)

Fig. 4. Working Model 2D simulation showing (a) the position of the two vehicles right before impact, and (b) accumulated frames of the simulation that matches closely the resting position of the bullet vehicle.

In addition, the effect of the drag between the wheel tires and the road surface has been modeled using four conditional forces, programed using WM 2D formula language to act only after the impact between the two vehicles has occurred (Figure 4). These forces (acting on the wheels) were set each equal to a quarter of the weight of the respective vehicle, times the friction coefficient between the road and the tire (also known as adhesion coefficient) and assumed to be equal to 0.7. According to his own statements, the driver of the SKODA did not press the brake pedal. However, an equivalent transmission drag force has been assumed in case of the impacting vehicle and was added to the simulation (see Figure 4-b).

4 RESULTS

The WM 2D model generated as explained above, fitted with control text boxes for a faster editing of the simulation parameters, has been run multiple times. The simulation for which the final position of the impacting vehicle matches closely that in the accident scene is provided in Figure 4. Due to the limitations of the software, the effect of the road ditch which stopped the side slipping of the BMW has not been included in this simulation.

None of the simulations with the SKODA moving on the second lane in its direction of travel resulted in the final resting position as documented in the accident report. It is not excluded however that the driver of the SKODA acted instinctively upon the steering wheel to avoid collision, something that he no longer remembers.

5 CONCLUSIONS

A road accident between two cars - a SKODA and BMW - that resulted in the side impact and the severely injuring of the BMW driver has been described. The litigation required the dismissal of the claim that the SKODA, the impacting vehicle, was traveling along the second lane, while in actuality it was passing outside the median. The accident has been reconstructed using Working Model 2D motion simulation software, with additional information about the accident scene being extracted from Internet-based digital maps.

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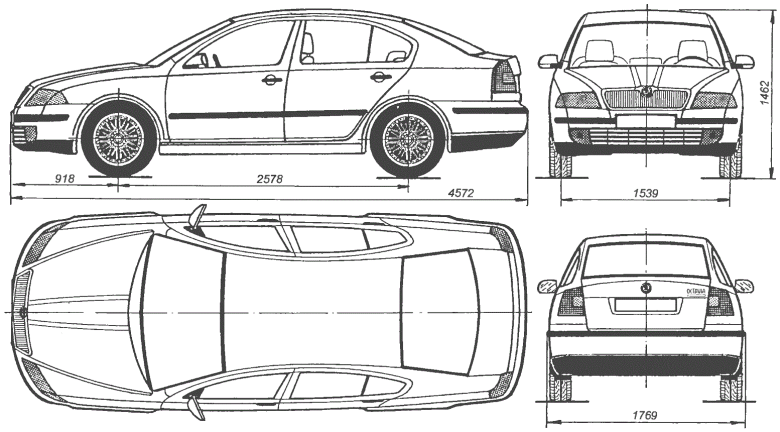
APPENDIX 1: Geometry of the 2004 SKODA Octavia



APPENDIX 2: Geometry of the 2004 BMW Series 3 Touring